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THE DOUBLE-CRESTED CORMORANT (*Phalacrocorax Auritus*) AND ITS RELATION TO THE SALMON INDUSTRIES ON THE GULF OF ST. LAWRENCE

by

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A.

B.

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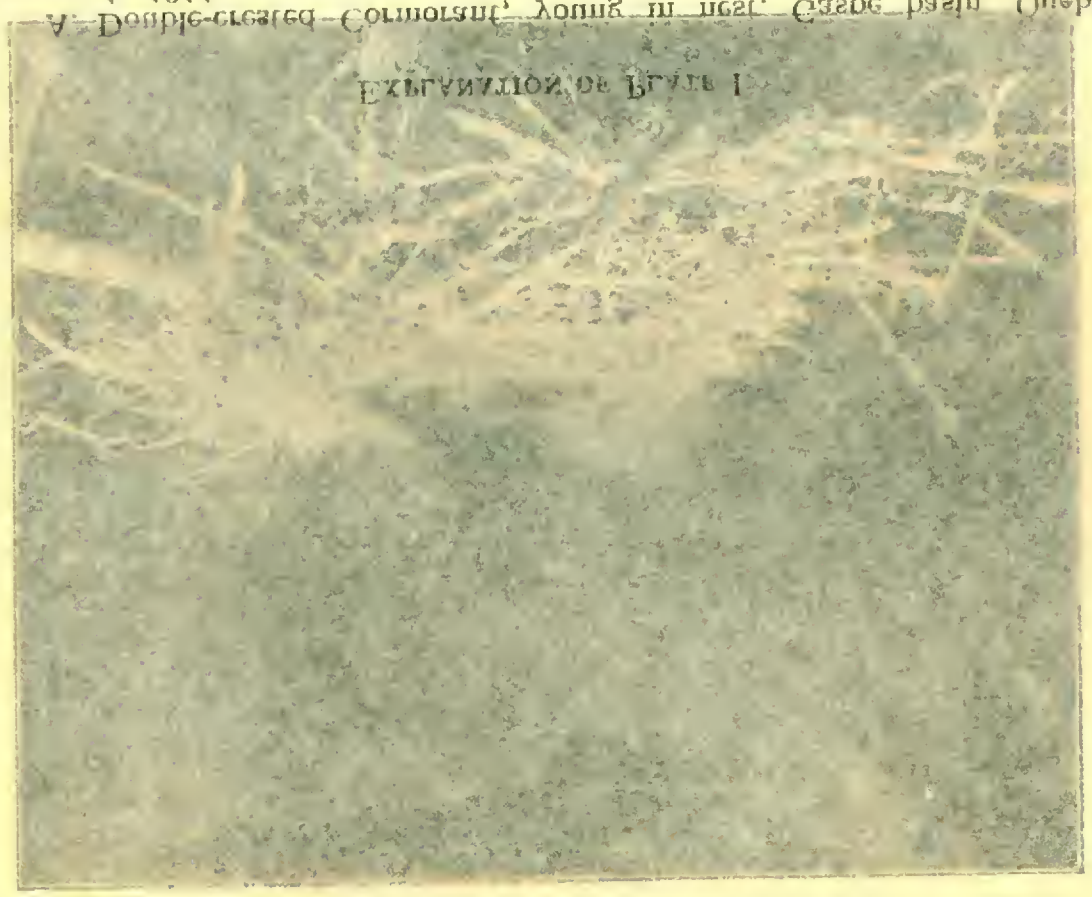

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By P. A. Taverner.

INTRODUCTION.

In the spring of 1914 the attention of the Geological Survey was called to complaints of damage done by cormorants to salmon fisheries of the Gaspe coast. As the charges seemed serious, and as systematic effort was being made to secure legislative assistance in controlling the damage, the writer was detailed by the Director of the Survey to investigate the charges and report upon them.

In pursuance of this object, accompanied by C. H. Young and F. C. Hennessey, I proceeded to Percé village, Gaspe county, Que., on the north shore and near the mouth of Chaleur bay, arriving June 21. We remained in this locality until July 24, collecting as many as possible of the birds and studying their feeding habits. We then removed to Gaspe basin and continued the work there for two weeks in greater detail, securing evidence from fishermen, river guardians, and others of experience on the salmon rivers. Throughout the work we were ably and courteously assisted by the local officers of the Fisheries department, especially Commander Wakeham of the *S. S. Princess*, Mr. Chas. Lindsay of the local hatchery, and Mr. Arthur Eden, his assistant, who was untiring in rendering assistance.

On August 10, we returned to Percé and finished the remainder of our work, leaving for Ottawa August 23.

DESCRIPTION AND LIFE HISTORY NOTES

OF THE DOUBLE-CRESTED CORMORANT.

The Double-crested Cormorant (*Phalacrocorax auritus*) belongs to the Steganopodes or Long-winged swimmers, an order characterized by having three fully developed webs to the foot. They are thus easily separated from other orders of swimming birds, the ducks, gulls, loons, etc., which are furnished with only two such webs, the space between the outer and the hind toes being vacant or with partial webs only as in the grebes.

This order of three-web footed birds is composed of five families three of which are represented in Canada by the Gannet or Solan Goose, the Cormorants, and the Pelicans. The cormorants can be easily distinguished from the others by their long, powerful bill terminating in a distinctly hawk-like hooked knob. The bill of the gannet comes to a clean sharp point, while that of the pelican is much flattened and furnished with an enormous throat or gullar pouch.

In eastern Canada we have two cormorants: the Double-crested (*Phalacrocorax auritus*); and the Common Comorant, identical with the Shag of Europe and England (*Phalacrocorax carbo*). Of these, the latter is slightly the larger and in adult plumage can be separated from the former by the occurrence of a white patch on the flanks and a border of the same colour along the edge of the small throat pouch. The adult Double-crested Cormorant, in the highest plumage, has a crest, on either side of the crown, of fine filamentous feathers, which is absent on the Common Cormorant. This crest, from which it derives its vernacular name, however, is not always present. It seems that some birds never attain it and others wear it for so short a time in the early breeding season that its value as a diagnostic mark is much reduced.

It is probably due to this frequent absence of a crest, that the cormorant inhabiting the Gaspe coast has heretofore been

generally incorrectly called the Common Cormorant. This species probably does occur but is not common. We examined many hundred birds at comparatively close range about Percé and Gaspe basin but did not detect any that could be mistaken for it, and it is not likely that they breed in the immediate neighbourhood.

The Double-crested Cormorant is a rather large bird, comparing favourably in this respect with a good sized domestic duck, but slimmer in build and more graceful in outline. Sitting in the water it has quite a loon-like appearance both in silhouette and action. The adult is solid black with green reflections over the most of the body plumage. The back feathers are vaguely margined with brown, making each feather appear to stand out as if in relief. Spaces about the eyes, and at the base of the bill, and a small though well developed gullar or throat pouch are bare of feathers and coloured bright orange. The eyes are green with purple edges to the lids and the interior of the mouth is a brilliant, almost cobalt, blue. The younger birds are dull brown, a little lighter below, and the facial colours much reduced in brightness. In the young of the year these bare patches are flesh pink with dull cloudings, but every gradation in colour of both naked and feathered parts appears at appropriate ages.

At Percé the cormorants nest only on the top of Percé rock. That great isolated fragment standing in the sea just off the salient point of the coast forms an ideal nesting place for them and the Herring gulls with whom they share the available space. The Rock, 2,100 feet long, about 80 feet wide on top, and nearly 300 in height, with smooth, sheer, unscalable sides, pierced through with its giant natural arch, is too well known to demand more than general remark here. The top is flat, gently undulating, and given up entirely to the bird association before mentioned. From a distance, the top of the rock appears in summer to be covered with sparkling frost or snow; but a closer inspection, from Mount Joli on the mainland, 800 feet or so away, resolves this frosting into white bodies of gulls and ground plastered with guano. Everything is white, not a blade of grass shows. Slight mounds here and there with birds perched on top

indicate nests merging smoothly in colour and outline into the surrounding surface. In the mornings the cormorants are seen flying away from the rock in singles and in small flocks of a dozen or more. In the late afternoon the greatest number return, but throughout the day birds can be seen both going and coming. About sunset most of the resident birds are in place on the rock. The gulls cover the less elevated positions and the few isolated crags, while the masses of dark bodied cormorants make nearly solid black splashes on the summits of the gently rolling elevations. At such times it was estimated that there were 1,000 cormorants on the rock, but as stragglers continue to come in until dark it is probable that the total population of cormorants on Percé rock is in the neighbourhood of 1,200 or 1,300 individuals. Local observers and residents place the number much higher, but I do not think their estimates can be substantiated.

Differing in habit from many sea birds, the juvenile and non-breeding cormorants seem to live during the nesting season in the same communities with the adult birds. Most water birds separate through the breeding season, the young and the adult birds occupying different localities through the summer, and not mixing together until after nesting duties are accomplished. On the Gaspe coast, however, old and young cormorants are seen constantly together, the latter evidently roosting at night in the immediate vicinity of their elders and accompanying them in mixed flocks to and from the feeding grounds.

About Gaspe the nesting and other conditions are quite different from those at Percé. Instead of occupying the top of one inaccessible crag they nest in different places on the shores of the bay, none very difficult of access.

On the north shore of the bay, about 3 miles out from Gaspe Basin, near a spot laid down on the pilot charts as "Three-runs," is a colony of about thirty nests built in trees growing from the top and upper face of the cliff and overlooking the sea at a height of about 150 feet. These trees are mostly small birches, with a butt diameter of from 4 to 6 inches, growing from the crest and upper face of the bluff and overhanging the narrow shore and the sea below. This site has probably not been long occupied

as it is not well known to the people about Gaspe. While the inhabited trees are evidently being killed by the deposits of fresh guano that copiously whitewash their leaves, trunks, branches, and the surrounding ground, many of them still retain enough vitality to put forth a few sickly leaves, and but few of them have been dead long enough to be rotten and brittle, a condition which occurs very shortly after the death of trees of this species. Though this colony is composed of about sixty adults there are probably twice as many juvenile and non-breeding birds attached to it and I estimate the total population of this rookery at approximately 180 birds.

Nearly opposite Three-runs and across the bay is a considerably larger rookery on a part of the broken cliffs locally known as Gull bay. Here the nesting is directly upon the broken ledges which rise some 120 feet from the sea. The nests are scattered about the rock face at various altitudes. Some nests are quite close to the bottom, others are just below the crest. They are on open shelves, behind jutting spurs, and in fractures in the face. The number was difficult to estimate, but from the birds visible, I should judge there were about three times as many here as at Three-runs, making about 540 individuals in all.

There is at least one other cormorant rookery reported in the vicinity, located around the point of Cape Gaspe and near Cape Rosier, but we did not visit it.

Though it had been reported that the Percé rock birds frequented Gaspe harbour and the salmon river mouths emptying into it, we saw no supporting evidence of it. Though we made the trip by water between Percé and Gaspe three times at various hours of the afternoon and early evening when the birds were flying homewards, we saw no cormorants between Cape St. Peter and Percé rock and observed very few within Gaspe bay to seaward of the before mentioned nesting sites—Three-runs and Gull bay. Whether the cormorants that are said to nest near Cape Rosier visit the harbour waters and their tributaries we cannot say; we saw no evidence of it. There is a break in the hills through which such birds might come and go, but we had little opportunity to observe fly lines through it, and from the

obvious reluctance of cormorants to cross land, and in the absence of other evidence, we consider that most, if not all, the cormorants seen about Gaspe are of the local population and not intrusives from other grounds.

Through the day practically all the cormorants, not brooding eggs or young, are found in the estuaries of the river mouths emptying into the bay. A few are occasionally seen on the waters of the outer harbour but they are only occasional in proportion to those regularly seen on the inner basin. Gaspe basin is the enlarged mouth of the York river separated from the waters of Gaspe bay by a narrow channel, a few hundred yards across. Within this narrow mouth it gradually widens to over a mile in width where, towards its head, it spreads over flat, marshy, island-filled shallows gradually narrowing to the river mouth proper some miles up. These wide tidal areas are just awash at low tide. At high tide they are covered by 2 or 3 feet of water. The bottom is mud well grown with eel grass. Along one side of the channel extends a long row of stout piles, retaining booms for the guidance of pulp logs, that are floated down stream during the freshets. Equally spaced along these piles are firm, stone-filled cribs to better withstand the pressure of flood and ice. In the morning as soon as the sun is well up the cormorants fly in through the narrow channel separating the basin from the bay, their numbers increasing until about nine o'clock when most of the birds are to be found fishing in the shallow water at the head of the basin. On first coming in they alight in the water, look about a minute, and then disappear with an easy gliding dive. They generally remain under the water for about a minute. If they have been successful in their fishing, their prey can be easily seen when they reappear. They catch a fish crossways and it takes a little manipulation and sundry jerks of the head to get it placed properly in the mouth; then there is an upward flirt of the bill and the fish is swallowed. A few gulps are given and the bird is ready to repeat the operation. When temporarily satisfied, the cormorants betake themselves to any near-by floating object or to the boom logs and piles lining the way. Sometimes every pile for half a mile or so acts as pedestal to an ebony black cormorant posing statuesquely on

or draped over the top, with wings half raised or hanging as if drying in the sun. I suspect that the cormorant is deficient in oily matter with which to annoint its feathers for it does not seem to be as perfectly adapted to aquatic conditions as most other water birds. Like its near relative, the Anhinga, which has a similar habit, it seems to find it necessary to dry its plumage after prolonged submersion. At such times it is a most awkward and ungainly sight, sitting with relaxed wings and body, limp and flaccid as a garment hung on a bush to dry.

The cormorants lay from 3 to 4 eggs, but there is a great mortality in the early stages of the nestlings. The eggs hatch one by one at considerable intervals of time and the eldest is a large strapping youngster before the youngest is out of the shell and, in fact, would hardly be supposed to belong to the same brood. It is large and strong and both requires and is able to take much more than its proper proportion of the food delivered; hence the disparity of size tends to increase rather than diminish as the brood develops. This undue development of one at the expense of the others was perfectly obvious in all the nests observed. The larger nestlings bully and badger their weaker brothers and sisters unmercifully, picking and worrying them continually. This probably helps to explain the fact that, as the chicks increase in age, there are invariably fewer in the nest until, in the latest stages observed, we did not see a nest that contained more than one bird. As a certain percentage of birds lose their entire brood in one way or another, I do not think that, on an average, a pair raises to adolesence more than one nestling each season. The fact, that, in spite of their slow rate of reproduction, the species is apparently increasing, points to the cormorant being a remarkably hardy bird, well adapted to its conditions, probably of long life, and without dangerous enemies. Throughout the day cormorants can be seen passing in and out of the basin, but in the afternoon about three or four o'clock the decided movement is outward to the rookeries and by sun-down the inner waters are deserted.

On July 18 I posted myself in the little pavilion opposite the Baker house, overlooking the narrow strait separating the basin from the outer bay, and counted the cormorants passing.

From 3.52 to 5.25 p.m. eighty-five birds flew outwards toward the rookeries. The movement had been well under way for some time and continued diminishingly for awhile after. Estimating that those counted represented a little less than half the birds frequenting the basin during the day, an ample allowance, I think, considering the comparatively regular habits of the birds, we have a total of 200 individuals regularly feeding in the mouth of the York river.

Another day I was passing on the river road at a point where an extensive view could be obtained of the cormorant-frequented water. With field glasses, I counted 100 birds in sight. As this view included the greater part of the area most densely populated by the birds it probably included at least half of their number, which agrees with the figure arrived at by the previous method of estimation, namely 200.

There are two other rivers in the immediate neighbourhood, the St. John and the Dartmouth, of like character to the York. Allowing an equal number of cormorants to the former and 300 to the latter would satisfactorily account for the remainder of the estimated 700 birds inhabiting the bay.

The food of the cormorant is practically entirely of fish. Probably a few crustaceans and molluscs are taken but in too small a number to be economically considered.

During our investigation, we collected some thirty cormorant stomachs. Though we did not weigh any of them, I should judge that the contents of a well filled one would average about a pound and a half. Assuming two full meals a day per individual would give for the Gaspe basin 600 pounds of fish consumed per day by cormorants, or, assuming that the birds remain in the estuary 5 months, from May through September, in constant numerical force, 45 tons per season. This is only a rough estimate as no special allowance is made for feeding the young or for the increase of fishing population when the young leave the nest and fish for themselves. But, as there is a general dispersing tendency among old and young of most species after breeding and before migration, basing our figures on a constant population for the whole season probably makes up for the deficiency. At any rate the estimate is close enough to show that should the cor-

morants of Gaspe seriously turn their attention to fish of economic importance their possibility of damage could be considerable.

In the vicinity of Gaspe and various other places on the coast the salmon (*Salmo salar*) is an economically important fish and furnishes livelihood to a large number of the inhabitants.

The mouths of the salmon-frequented streams are lined with their full legal quota of nets which supply the fish to the general market, bringing good prices and furnishing business and profit to the fisherman, the middleman, the retailer, and to the common carriers connecting them. The streams themselves are owned by, or leased to, private individuals and angling clubs, and are, therefore, not open to public fishing. The law allows only fly fishing upon them, the catch, therefore, is limited and cannot be looked upon as an economically important food supply. However, the owners of the streams are necessarily men or clubs of wealth and distribute considerable money in the immediate neighbourhood, besides paying a comparatively high rental to the Provincial Government for the privilege. Club houses are built, canoes and outfits bought, guardians and wardens salaried throughout the year, and numbers of guides employed intermittently during the season. Food supply for members has also to be provided on a rather elaborate scale, most of which is procured locally, and general service paid for. Added to these expenses, the railway fares and expressage necessary to transport men and their trophies to and from the ground, and the innumerable other ways in which wealth, when on a holiday, distributes money totals far beyond the mere food value of the fish actually taken in the river and forms an important item in the welfare of the community.

There may be another side to the story, of course. The food supplied to society in general may be a mere bagatelle compared with the effort and money spent in obtaining it and may indicate economic waste. However, be this as it may, the fact remains that the angling interests are esteemed of extreme importance to the local communities about the Gulf of St. Lawrence and the possibility of cormorants being harmful to their welfare demands careful investigation.

Amongst the anglers of the Gaspe coast there are many complaints against the depredations of a few species of birds. The salmon net-fishermen and other professionals are not insistent, but the clubs are decided in their charges and have even gone so far on many streams as to place bounties upon the heads of the supposed worst offenders. Such bounties have been established upon the St. Johns and the York rivers according to the following scale: Cormorants, sheldrakes, kingfishers, and divers 25 cents per head, and for a kingfisher's nest with female bird $2.

Elsewhere than about Gaspe I have heard few complaints against cormorants, but in this locality they are popularly regarded as the worst enemy of salmon and application has been made to have these bounties supplemented by a Provincial grant.

Evidence apparently against the cormorants is not wanting. Knowing that all the salmon smolt must pass through the estuarine mouths of the rivers to the sea and again repass them when ascending as grilse the presence of numbers of fish-eating birds of itself is disturbing enough, but when one hears from reliable sources that some twenty-seven fingerling salmon (parr) have been taken from the crop of one cormorant, the evidence superficially looks alarming. Investigation, however, shows that these constantly reported tales are variants of a few cases so often repeated as to greatly exaggerate their importance and hide their exceptional character. But all cormorants found on the upper reaches of the rivers must, until other evidence is forthcoming, be assumed to eat salmon, as they and a few trout are practically the only fish the waters contain.

According to our experience, supported by the evidence of various experienced rivermen, guides, guardians, and fishermen, cormorants rarely ascend the rivers beyond tide influence, but congregate in the shallow saline water of the estuarine mouths. From various frequenters of the rivers we heard that one rarely sees more than half a dozen cormorants within the river proper throughout the year. During our stay we saw and took one bird barely above tidal influence and later obtained two more shot by others in the same vicinity. Our bird we knew by observation

had been fishing for at least an hour and a half, but its crop as well as those of the other two mentioned were empty. The rarity of the species in river waters shows that these accidental occurrences before cited must be disregarded in considering the economic damage done by cormorants to salmon.

With the exception, then, of a few wandering birds, the cormorants feed either along the sea coast as at Percé or in the tidal mouths of the rivers. We collected some thirty stomachs from such localities, but none of them contained salmonoid remains. The food contents were mostly capelin, flounder, herring, and an occasional eel and tom cod. See table of stomach contents, page 15.

Of the thirty-two stomachs examined, five were empty, one so nearly so as to make the contents unrecognizable, and two were from nestlings with contents regurgitated from the parents throat, and, having been subject to double digestive action, were not recognizable.

Of the remaining twenty-five, sixteen contained sculpins; five herring; one each capelin and eel; and two tom cod or allied fish. Nearly all had *ascaris* and other parasitical remains. The evidence indicates that these were incidentally obtained from the flesh of the original hosts. In many stomachs there were fragments of eel-grass, crustaceans, molluscs, and pebbles, but in small quantities and evidently derived from the stomachs of the prey or taken accidentally with it.

It will be seen from this that the cormorants in the tidal mouths, at least during the season of our work, July and August, do little, if any, appreciable damage to the salmon. It yet remains to be proved that they are equally harmless at other seasons though, as will be shown from later considerations, the onus of the proof rests with the prosecution.

On the coast, about Percé, the cormorants certainly do the fishermen a certain amount of injury. It is not the salmon industries that are affected here but the cod-fishing. During a large part of the season the codfishers rely altogether upon herring for bait and for this purpose the herring nets are set nightly. When these fish are abundant the toll taken by cormorants is not noticeable, but when, as regularly occurs, herring are scarce,

the birds go to the nets and help themselves to the contents. The few herring they take are on the whole only a bagatelle; but when half a dozen small fish is all that can be expected from a net to serve for a day's fishing, and half or more are taken by cormorants, the fishermen can hardly be criticized for giving vent to some evidences of discontent at the loss of a day's work and profit. However, though the fishermen do look upon the cormorants as one of their natural enemies, they do not seem to be bitter against them; not nearly as much so as the salmon anglers, who only have a sporting interest in their fish and are not dependent upon them for a livelihood. The best protection for the herring in the nets against the cormorants appears to be to lift the nets early in the morning before the cormorants commence to fish. Recourse may be had to frozen bait, caught when herring are plenty and preserved for times of scarcity. This has been tried and, according to reliable reports, with good success by those who gave it a fair trial; but the majority of the fishermen are too conservative to adopt new methods and the freezing apparatus was a financial failure and was discarded.

The life history of the Atlantic salmon seems to be about as follows. The eggs are laid in the sand at the headwaters of the streams in the autumn, being deposited by the female and fertilized by the male who then covers them with sand. In the spring they hatch and the young, still with a large sac of egg yolk attached, seek safety in the crevices of the rocks until the sac is absorbed, when they begin feeding and gradually spread down stream. Here they remain two years growing into fingerlings or, as they are technically called, parr. At this stage, when they are about 4 inches long, they proceed to deep water as smolts. Authorities differ as to the time spent at sea in this stage, and some doubt is expressed as to whether the typical smolt characteristics are developed before or after entering salt water. When they again ascend the streams they are grilse, with a weight of from 2 to 5 pounds. They descend to the sea at the end of the season to come back the following year fully developed, 20 to 40 pound breeding salmon. The adult salmon does not feed in fresh water until after the eggs are deposited and fertilized. The trip is long and arduous and when the

propagation duties are over, both sexes are thin, worn, and unfit for human food. In this condition they pass down stream under the name of kelts to be rejuvenated in salt water and made ready for successive breeding migrations in following years. It seems to be yet an open question as to whether the kelt feeds in fresh water. General opinion indicates that they may do so, but definite data on the subject are difficult to obtain. If they do it must be at the expense of their own race—the parr, smolt, and perhaps grilse. It is evident, then, that the salmon have to run the gauntlet of their enemies in the estuaries once as smolts, twice as grilse, and again annually as long as they breed as salmon and kelt. The grilse are large enough to be practically safe from attack by cormorants except, possibly, the smallest and weakest whose weeding out is beneficial to the race. The salmon and kelt are obviously beyond danger from birds. There remains then, only the parr and smolt that have anything to fear from cormorants and these only as they are making the passage from fresh into salt water. The work has shown that during July and August either there are no smolt in the tidal mouths of the rivers or else the cormorants do not catch them. Though it is difficult to get exact data on the subject it seems, from the information at hand, that the journeying of the smolt to the sea is not accomplished in one general migratory movement but that they drift out continually during the summer months and that July and August conditions are fairly typical of the whole spring and summer season. If this is correct, the cormorants must be acquitted of any serious injury to salmon; if it is not, evidence to the contrary must be submitted. The food eaten by any species is governed largely, within certain more or less widely defined lines, by its availability. Cormorants probably eat practically any small fish they can catch, but any hunter knows that only one kind of game can be successfully hunted at a time: the hunter after deer rarely sees birds; the collector of ground birds misses the species over-head, and so on. Concentration in one direction blinds us to what is happening elsewhere. Occasionally the unlooked for does appear; but it is generally more or less of an accident and does not negative the foregoing rule. Hence creatures of prey hunting for bottom

haunting species will generally neglect free swimmers and only capture occasional individuals that accident brings to their attention, nor will they without good reason neglect an abundant, easily captured food supply for a scarcer and more agile prey. The salmon at all stages is a free swimming fish, very agile and quick in its movements. The sculpin, on the other hand, is a ground feeder, hugging the muddy bottom, and is more easily caught than strong swimming salmon; therefore, so long as the former are present in numbers, the latter are not likely to be hunted or pursued extensively. The fact that the birds we obtained from the sculpinless reaches of the river near the mouth had empty stomachs, supports the view that salmon are difficult of capture. The one bird that we know had been fishing in salmon waters without results for an hour and a half further corroborates this view.

From all reports, the salmon in the rivers have been lately increasing from year to year. One experienced man says that ten or twelve years ago about thirty fish were taken in the York river per year, while in 1913 from 120 to 130 were caught by anglers. The cormorants are also generally increasing in number, the rookeries are enlarging and new ones being established. These facts taken together do not indicate that the cormorants are markedly harmful to the salmon. In fact, they may be more beneficial than harmful as a whole, in helping to weed out the weak and unfit fish, and so keeping the stock up to virile strength. The danger of removing all predacious influences was well shown by the grouse plague in Scotland when it was decided, by the investigating committee, that the great spread of the disease was due to the destruction of the vermin that normally, quickly, eradicated diseased or weakly birds before they had a chance to contaminate the remainder of the flock. From the evidence on hand it is, therefore, evident that the cormorants in the fresh water reaches of the rivers are few; that those in the tidal mouths feed on bottom haunting fish, and that as a whole the influence of cormorants upon the number of salmon can be disregarded as too slight to be of economic importance.

Tabular Results of the Examination of Thirty-two Cormorants' Stomachs, 1914.

No.	Locality	Date	Sculpin	Herring	Capelin	Eel	Flounder	Tom cod	Remarks.
87	Percé	June 21	T						Sea shore.
90	"	"							Empty
96	"	June 25							Empty
102	"	June 28	S	1					Sea shore
103	"	"			9				" "
147	"	July 10	1						" "
173	Gaspe	July 29	3						River mouth tidal.
174	"	"	6						" " "
175	"	"				1			" " "
187	"	"	S						" " "
188	"	July 30		S					" " "
189	"	"	7				2		" " "
190	"	"	T						" " "
191	"	"		T					" " "
192	"	Aug. 3						1	" " "
193	"	"	←T→						" " "
194	"	"	T						" " "
195	"	"	1				1		" " "
196	"	"		T					" " "
197	"	July 29	T	T					" " "
198	"	Aug. 3						1	" " "
199	"	"	2				3		" " "
200	"	"					1		" " "

Tabular Results of the Examination of Thirty-two Cormorants' Stomachs, 1914.—(Continued).

No.	Locality	Date	Sculpin	Herring	Capelin	Eel	Flounder	Tom cod	Remarks
201	"	"	2						" " "
202	"	"	2						" " "
203	"	Aug. 4							Nestling
204	"	"							"
209	"	Aug. 19	T						York river
210	"	"	T						" "
...	"	"							" "
			16	5	1	1	4	2	

T = traces. S = several.

In No. 193 the remains could not be accurately determined except that they belonged to either of these species. Two more stomachs were collected but being absolutely empty they were not saved or recorded.

The fragmentary remains of food in these stomachs made determinations difficult. However, the fine bones of herring and the angular, spinny fin-rays of the sculpin are too characteristic to be easily mistaken. In other cases species could only be recognized by the presence of ear bones (otoliths), in the finely comminuted masses.

In order that no mistake should be made in recognition of these remains the aid of the Marine and Fisheries Department was solicited. Mr. Andrew Halkett of that department was, therefore, detailed to assist us and he personally passed upon all the material here presented.

SOME GENERAL PRINCIPLES BEARING UPON THE ARTIFICIAL PROPAGATION AND INCREASE OF SALMON AND OTHER SPECIES.

As the investigation of the influence of cormorants upon salmon has brought up questions of damage done by other species of birds, it seems well to discuss some general principles that should have consideration in dealing with this and allied subjects. These may seem of a speculative character, but they are really fundamental principles, founded on proven examples

and actual cases, and neglect of them may lead to misdirected efforts, expensive failures, and even positive harm. The destruction of species harmful in one direction has often caused incalculable damage in others, far outweighing the benefit expected.

Innumerable examples can be cited where the disturbing of the balance of nature has resulted disastrously, in cases of both removing from and adding to a fauna. Under changed conditions, some of the most innocent seeming species have developed unsuspected harmful traits and others apparently the most worthless have been seriously missed when removed. The balance of nature is too delicately adjusted to warrant our interference, until after exhaustive investigation and careful weighing of evidence pro and con. Even then, the problem is too complicated for any one to confidently prognosticate the final resultant conditions, and a certain amount of doubt always remains until practical results test the conclusions.

Leaving out the practical economic questions altogether, common humanity prompts us to destroy life only when necessary. Man having great power for good or evil in nature has consequently equally great responsibilities. It is not enough to prove that a species is "useless" to justify its persecution; it must be proven to be actively harmful before such a course is justified, not in a slight degree, but in a manner that seriously threatens our welfare. Even then the edict of extermination or persecution should only be pronounced when all other remedies fail. The neglect of this responsibility invariably reacts upon our heads. Even should we not thereby destroy unrecognized friends, we foster a disregard for lower life amongst our people that is often evidenced by the slaughter of other harmless or beneficial species. Bounties upon destructive hawks such as the Goshawk, and Cooper's Hawk have time and again been death warrants to Sparrow Hawks and others whose influence is decidedly and actively beneficial to the farmers and mankind in general. The placing of shot guns in the hands of irresponsible persons at all seasons tends to nullify our game laws, valuable species suffer, and protective measures are made more difficult to enforce.

As it is, the useless slaughter of non-game life that now goes on in certain parts of our country is deplorable. The sight of hundreds of dead and wounded gannets shot near Percé during the summer of 1913 for sport (?) and left to lie where they fell indicates not only a wanton and unnecessary waste of innocent life but a looseness of moral fibre among certain people that is a danger to the country at large and should be curbed. The attitude of our laws should instil a wholesome regard for the rights of lower life and the taking of it uselessly should be discouraged in every way possible. This does not mean that a sentimental quixotic stand should be taken. Whenever the end justifies it, no weak sentimentality should be allowed to stand in the way of human welfare; but the spirit of our laws and people should be such that no creature should be destroyed without a good, sufficient, and well considered reason.

For a proper understanding of the principles to be considered before a species is condemned, the following points bearing upon the subject are advanced. The number of a species is dependent upon three main factors: food supply, enemies, and birth rate. In order of importance they vary with the species and the conditions, permanent and fluctuating, under which they live. For the purpose of the present paper, and as they relate to salmon vs. birds, the above order of importance probably represents normal comparative values.

The birth rate being controlled within the species itself, through the influence of evolution, is flexible and can reasonably be supposed to have reached that stage, in any dominant or successful species, most profitable to it under existing external conditions. It is, therefore, self-correcting and can be placed last in the list. The birth rate is, in any thrifty race, always much higher than is necessary to merely replace worn out individuals. When it is realized that a pair of adults in a stationary population, can on an average raise to maturity only an equal number of offspring during their life time, it is evident that the death rate in all species is enormous. It is also evident that the natural birth rate is sufficient for all practical purposes and unless the death rate is high during adolescence, the species would, in a few generations, increase beyond all reason.

Food supply is largely dependent upon conditions outside the species and without its control; inasmuch as food habits can be changed, within certain broad lines, they are flexible. Should the usual source of supply fail, the species can usually adapt itself to others. However, food supply must be obtained and is a most important agent in limiting the numbers of any and all species. It is also a necessity that occurs throughout the life of an individual. It avails nothing that food should be abundant for the adult if it is scarce or absent during development. The effect of starvation is immediate. A subnormal birth-rate reduces population slowly, acting over generations. Reduction of numbers through enemies may be much quicker and completed within a few seasons or less, but starvation acts almost instantaneously and in most cases is an operation of days instead of weeks, years, or generations.

The effect of enemies upon a species is complicated in results; the species preying and preyed upon re-acting on each other in various ways. In general, a species is seldom if ever absolutely exterminated by these means. As soon as a food animal becomes too scarce to be profitably hunted, its pursuit is neglected and thereafter only occasional or accidental individuals are taken. On the other hand, any marked increase of food animals is followed by an increased attention from their present enemies and an influx of new ones from adjoining territories. If reduction of food supply stopped when normality was reached the result would be comparatively simple, but, while the number of enemies in the locality is supernormal their food supply has at this stage been reduced to normal. Attention is eventually turned towards other food sources, but, as the enemy population is temporarily greater than the supporting powers of the habitat, it is unusually active and keen, hunting more carefully, with greater persistence than usual, and consequently with greater effect. For a while, at least, the reduction process is thus continued and the food supply, or species preyed upon, falls below normal. Finally, however, the enemies also are reduced either through starvation or movement to other localities until their population is also brought below normal numbers in harmony with the reduced resources of the habitat.

This gives the food species opportunity to increase once more to abnormal numbers and the process begins over again in a diminishing degree. Thus an oscillation is started that may take considerable time to subside to stable normality.

The final population of a species then, depends upon a complexity of influences and is the resultant of many forces acting along different lines and at various angles, each interrelated with the other and having differing values as their opposing forces are readjusted.

There is a certain definite maximum of population beyond which a species cannot go. We have many evidences of this. One of the most obvious was the case of the Bluebird in the winter of 1894-5 when this common species was almost wiped out in the south. For five years the species increased rapidly to normal population and then stopped short. As far as we can see no new factor was introduced, no enemy absent during the five years of growth was present in the sixth year, the food supply and birth rate seemed constant throughout, but the increase was definitely and positively checked during the fifth year. It is obvious that a limit to the Bluebird population had been reached.

In estimating the effects of any set of conditions upon the lives of a species, there will always be found one or more factors having a predominating influence upon it. There is always one critical time or stage in its life that practically determines its numbers. Just what this is, is difficult of determination in any given species. Of course, should this factor be removed the next most important one takes its place as the critical moment, and after it another appears. Any relief to be effective must be applied at these critical moments in their proper succession. For instance an increase in food supply in summer or reduction of enemies would not permanently profit a species if the limiting factor to its numbers was the sufficiency of food in winter or southern ranges. With the above principle in view, let us consider the effects of cormorants and other birds of prey upon salmon.

The number of adult salmon is the result of birth rate, modified by the amount of food supply, less the number taken

by enemies before reaching breeding maturity. The birth rate we can assume as being sufficient under normal conditions. But the introduction of man with his efficient and deadly methods of taking fish after they have passed the gauntlet of natural enemies, has introduced a decidedly adverse and abnormal influence against the species. The mature fertile fish is nature's finished product, the outcome of that fine balance it has taken ages of adaptation to evolve and secure. Loss at this stage will be more keenly felt by the species than at any other time in its life-history and, unless compensated for, is bound to have a marked effect upon the total numbers. It is not only the individuals themselves that are lost in this case, but the generation they are about to give rise to, and for which the whole economy of the species has been formed to produce. The proper correction for this is the hatchery which, in so far as it compensates for the eggs of those fertile individuals taken by man, should be sufficient to keep the salmon to the standard allowed by the resultant of other forces. However, no increase in final population beyond the normal capacity of the stocked waters can be expected from these means unless there is food supply for an increased number of the species at all ages. This food supply has to be considered throughout the species' range. The salmon in the sea seem to feed largely upon such fish as herring, and upon crustacea, both of which are plentiful, and there is little probability of their insufficiency. In the streams it is another question and a determination is less easily arrived at. The fry undoubtedly feed upon microscopic animalcules, the sufficiency of which may be tentatively assumed with moderate safety, but we have yet to learn the food supply of the fingerlings or parr. The water of the streams visited is absolutely clear, the bottoms are clean gravel and rock, with no visible abundance of algal, plant, or insect life. There is undoubtedly a certain amount of some such food, but it is too scattered to attract the attention and is obviously insufficient for the support of an unlimited number of fish.

We found that the parr do eat fry of their own species most greedily. As all the fry in the salmon streams are those of salmon and of a few trout the inference is plain, that a large part of the

parr are supported by fry. How many fry it takes to raise a parr to the smolt stage we cannot tell, but it must be an enormous number.

The shelldrakes (mergansers) are accused of devouring the salmon ova. Considering that the ova is buried in the sand immediately after being fertilized and is guarded by the male, while this is in process, it is not likely that the number taken by these birds can be a very large proportion of the whole and must be small in comparison with the number of fry taken by the parr. At this stage, the worst enemy of the salmon is undoubtedly the salmon itself.

The parr, to the smolt stage, are thus obviously limited in number by the amount of fry in the river. If it can be established that the kelt or grilse eat in fresh water they are probably the parr's worst enemy. If not, that distinction falls to the lot of the kingfisher who undoubtedly consumes considerable numbers of them.

Whether they seriously reduce the final number that go to the sea as smolt is a question of more than one aspect. A reduction of parr means an increased number of fry and, therefore, more food for the remaining parr who being better fed may be stronger and more fitted to survive later dangers. If the birth rate is markedly greater than the food capacity of the streams, kingfishers may have no harmful effect. They should not be finally condemned until this point is investigated.

The population of fry produced by the birth rate is greater than can be raised and the surplus must necessarily be reduced, if not by one agent, then by another. There is a point to be reached when even an immense increase in the number of fry introduced into the streams will be ineffective in increasing the output of smolt. As the birth rate has been evolved under present conditions of food supply and enemy factors, the natural conclusion is, that the kingfisher and the shelldrakes are compensated for in it. The natural increase was sufficient to stock the river in the past to abundance, in spite of these enemies, and there is no reason to suspect that it is less effective now. Hence if man introduces sufficient fry to compensate for the ova that should be laid by the breeding

fish he captures, probably the highest possible efficiency of the streams under present food conditions will be reached. If this is done shelldrakes and kingfishers can be neglected except to see that they do not increase to an abnormal extent.

As the smolt go to sea they pass the gauntlet of the cormorants, but these, I think, we see, have little or no effect upon their number and can be neglected.

What happens at sea to the smolt, grilse, and salmon at present none can tell. In the teeming abundance of marine life their food can be assumed to be plentiful. The rapidity with which a fingerling smolt grows to a five pound grilse is sufficient evidence of this. The most serious limitation to numbers at sea must come from the salmon's many enemies. In the final stage of the salmon's existence before maturity lies probably the factor that determines how many will re-ascend the streams to procreate their species and incidentally become available for human use. As said before, a food species is consumed by its enemies until it becomes too scarce to be profitably hunted. A notable increase of food supply attracts new consumers and the resultant population is apt to be little, if any, greater than before. With the enemy factor controlling the situation the number of resultant food fish seems to become a matter of population per unit area of ground occupied.

For example, assume that ten salmon per acre is scarce, i.e. that population is too scattered to be profitably hunted, and the expended energy in finding and capturing a meal of salmon is considerably greater than would be expended in pursuit of other species or in other quarters; the salmon under these conditions and assumptions will cease to be systematically hunted by its enemies and, except for occasional and accidental encounters, will enjoy comparative immunity. Should the population be suddenly increased to fifty or a hundred per acre, it will be salmon season for their enemies who will abandon other usual prey for the new abundance. Should the resident enemies find more than they can consume neighbouring competitors will be attracted, and it will not be long before the population is reduced again to the old ten per acre and comparative peace will be resumed.

It is evident then, that any method of raising this deep sea salmon population above the economic mean of ten per acre (number here arbitrarily assumed) will be wasted energy and expense unless the enemies at this critical time can be controlled. If, as seems likely, the deep sea condition is the controlling element in the life of the salmon, increasing the number of fry, feeding parr or destroying fresh water enemies will have little if any effect on ultimate numbers.

Protection at other times will no more increase the number of mature salmon than enlarging two ends of a pipe, while leaving a constricted length in the middle, will increase its flow capacity.

In conclusion it may be said that

I. The total effect of bird enemies upon salmon is small, if any.

II. Hatcheries and fry planting will compensate for the toll of mature fish taken by man.

III. The number of smolt that go to sea is dependent upon the food supply in the streams.

IV. The number of returning salmon is governed by the extent of their deep sea habitat and the number of enemies there.

V. While planting may return an exhausted stream to its normal capacity, the number of fish cannot be indefinitely increased without a readjustment of other critical conditions.

VI. Eliminating the question of poaching, stream defilement, and other abnormal conditions the problem of increasing the salmon run in the rivers, above the natural capacity of the streams, lies between increasing the parr food in them or reducing the enemies of the salmon in the deep sea habitat.

The first number of the Museum Bulletin was entitled, *Victoria Memorial Museum Bulletin Number 1.*

The following articles of the Biological Series of Museum Bulletins have been issued.

Biological Series.

1. The marine algae of Vancouver island; by F. S. Collins.

2. New species of mollusks from the Atlantic and Pacific coasts of Canada; by W. H. Dall and P. Bartsch.

3. Hydroids from Vancouver island and Nova Scotia; by C. McLean Fraser.

4. A new species of Dendragapus (*Dendragapus obscurus flemingi*) from southern Yukon Territory, by P. A. Taverner.